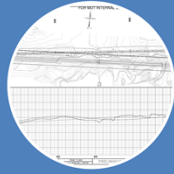




# Geotechnical Features

**D.J. Berg, P.E. - Glendive District Geotechnical Manager**

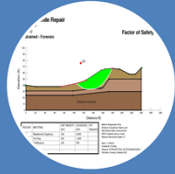
# Geotechnical Design Process



Geotechnical  
Features



Site  
Investigation



Geotechnical  
Design

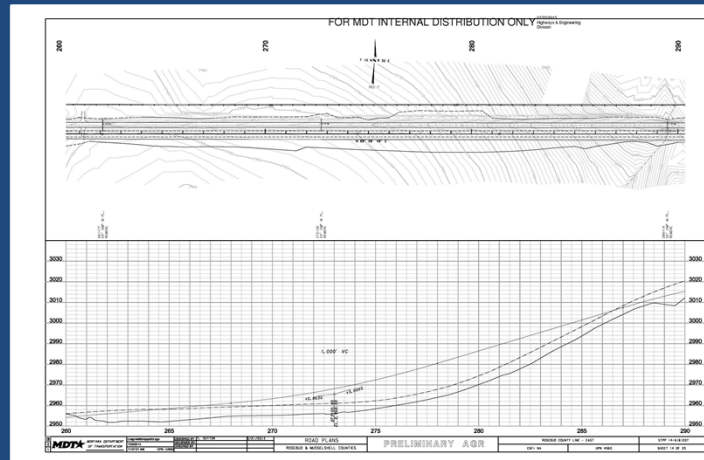


Construction



# What is a Geotechnical Feature?

Identified by thinking critically about design and construction of roadway elements.



## What is a Geotechnical Feature?

Mostly related to earthwork and foundations.





# What is a Geotechnical Feature?

Sometimes include unusual problems.



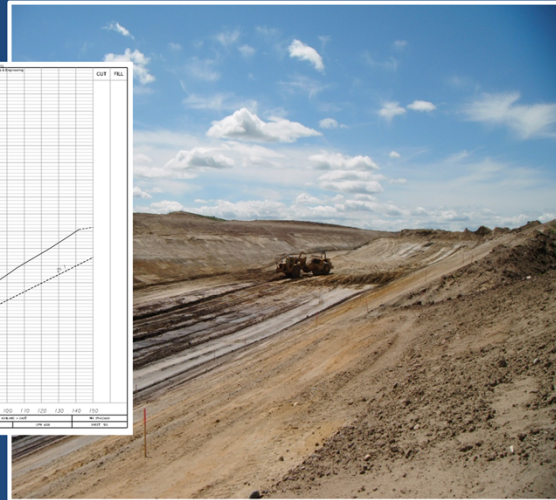
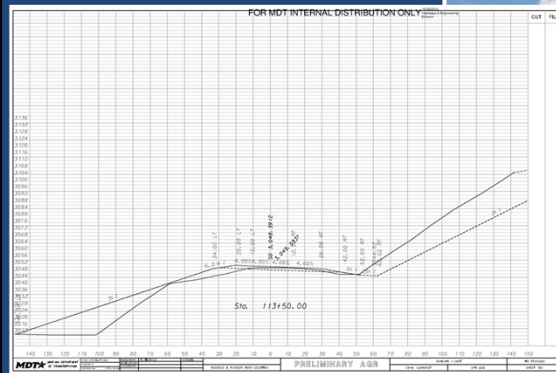
## Major Geotechnical Features

- Cuts/Fills
- Embankment Over Soft Ground
- Rock Slopes
- Retaining Structures
- Pipes
- Structure Foundations
- Landslide Corrections



# Cuts/Fills

## Slope Design



Primarily driven my Slope Stability analysis, short-term and long-term

## Cuts/Fills

### Subgrade



**G. Digout.** In areas of digout, excavate the full road width to a depth as shown in the contract or as directed by the Project Manager. Excavate parallel to the finish grade, daylighting to the left and right slopes. Slope the ends of the digout no steeper than 4H:1V. Dispose of the excavated material to the satisfaction of the Project Manager.

Provide special borrow for digout replacement material consisting of a well-graded sand and gravel, free of organic and other deleterious material, meeting the AASHTO M 145 requirements for A-1-a group classification, with 100% passing the 2-inch (50 mm) sieve and a maximum of 8% passing the No. 200 (0.075 mm) sieve. The material may consist of up to 50% millings, uniformly blended. Crusher fines and reject material may be used if the requirements in Table 701-22 are met.

Provide stabilization geotextile that meets the requirements of Subsection 716.03 for Stabilization geotextile.

Place stabilization geotextile over the bottom and sides of the excavated digout area in conformance with Subsection 622.03. Extend the geotextile up the side walls of the excavation for the full height of the exposed subgrade soils.

Place the initial lift of special borrow over the geotextile in accordance with Subsection 622.03.2.

Repair any geotextile damaged during construction in accordance with the Manufacturer's recommendations or as directed by the Project Manager at Contractor expense.

# Cuts/Fills

## Unsuitable Material



### SPECIAL PROVISIONS

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#### 1. COAL WASTE

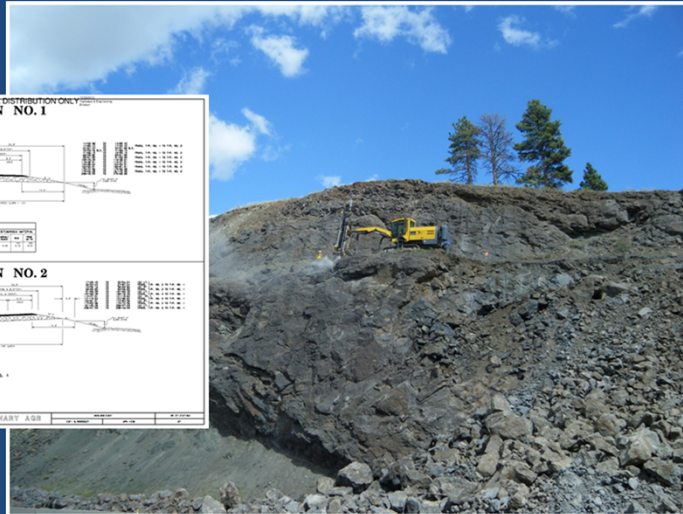
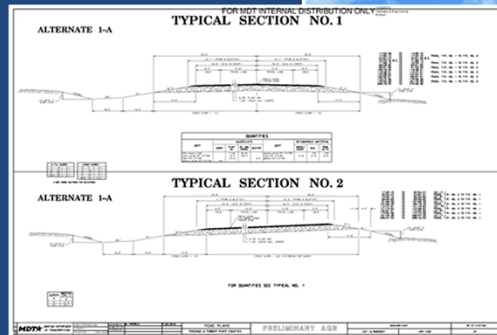
A. Description. Remove and dispose of any coal found within the roadway excavation.

B. Construction Requirements. Waste all coal encountered in excavation on construction fill slopes or suitable location approved by the Project Manager. Cover with a minimum of 1 ft of excavated material including placement of topsoil. If coal is encountered at subgrade in cut sections, excavate to a minimum depth of 2 ft below subgrade elevation and full width of planned pavement section. Backfill with Special Borrow in accordance with Section 203.03.3.

C. Measurement and Payment. Include the cost to waste coal as outlined above including haul and placement, in the unit bid price for unclassified excavation.

Digouts, Subexcavation, Coal Waste

# Cuts/Fills Constructability

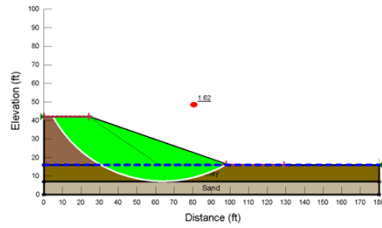


# Embankments Over Soft Ground

## Stability (Bearing Capacity)

**Culvert S of Opheim**  
 UPN 8863000  
 Station 468+00  
 Short-term Analysis

**Factor of Safety: 1.62**



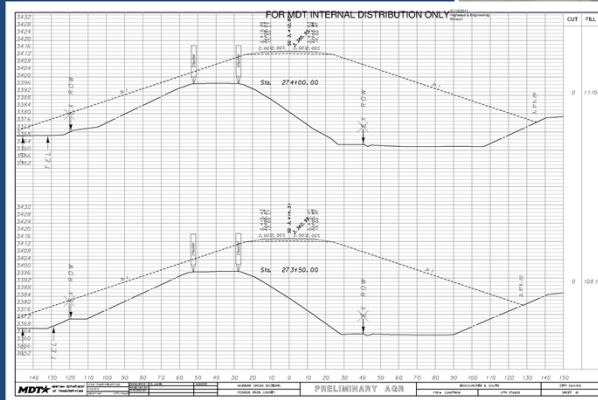
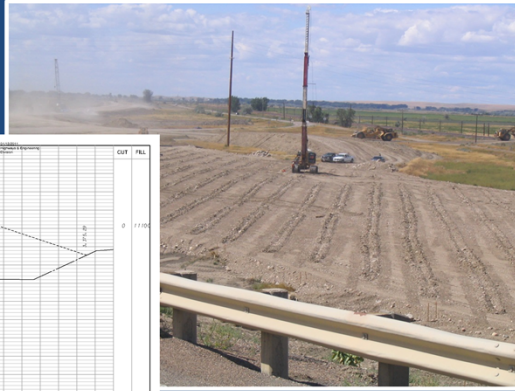
REGION	MATERIAL	UNIT WEIGHT (pcf)	COHESION (psf)	Phi (degrees)
1	Sand	125	0	34
2	Clay	120	670	
3	Embankment	120	0	30

Method: Morgenstern-Price  
 Direction of movement:  
 Slip Surface Option: En  
 P&P Conditions: Span  
 Minimum Slip Surface: I  
 Date: 10/25/2016  
 Created By: D.J. Berg  
 Directory: S:\PROJECT  
 File Name: STA\_468+00

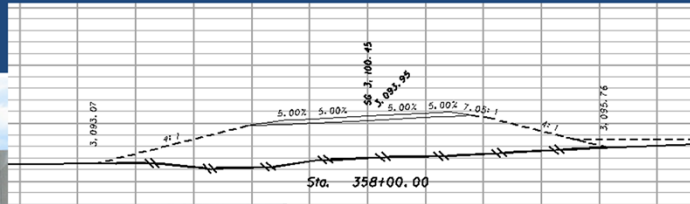




# Embankments Over Soft Ground Settlement







# Rock Slopes

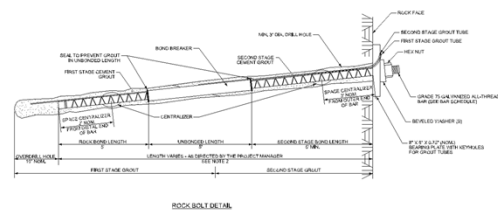
## Blasting




# Rock Slopes Stability



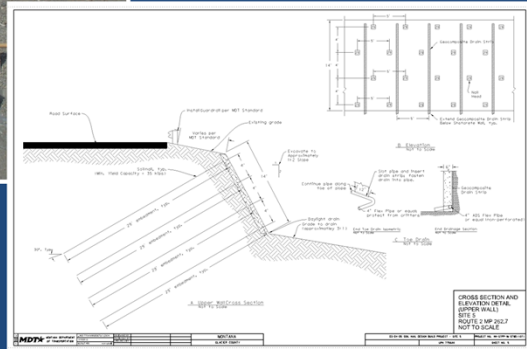
**DETAIL**



# Rock Slopes Protection



The image is a composite of two parts. The top left is a photograph showing two workers in safety gear (hard hats, high-visibility vests) installing a wire mesh on a steep rock face. A yellow crane arm is visible on the right. The bottom right is a technical diagram of a rock slope protection system. The diagram shows a wire mesh, an anchor system, and a rock nail. Labels include 'ROCK NAIL', 'ANCHOR SYSTEM', 'ROCK NAIL (TOP)', 'ROCK NAIL (BASE)', 'ROCK NAIL (SIDE)', and 'ROCK NAIL (BOTTOM)'. It also shows a 'ROCK SLOPE' and a 'ROCK NAIL'.



## MSE, Soil Nail, Gabion, Gravity, Cantilever

# Retaining Structures

## Stability/Drainage



Stability of wall (bearing capacity, sliding, global stability)

Drainage components

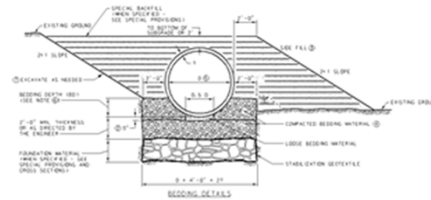


# Retaining Structures

## Constructability



# Pipes Settlement





# Pipes

## Constructability

### SPECIAL PROVISIONS

CONTRACT NO. [Click here to view](#)

#### 1. CULVERT FOUNDATION TREATMENT (REVISED 12-11-15)

A. Description. Prior to culvert placement, construct the culvert foundation, consisting of culvert excavation, geotextile placement, and foundation material placement locations shown in the plans or as directed by the Project Manager.

##### B. Materials.

- 1) Provide **Stabilization** Geotextile meeting the requirements of Section 711.
- 2) Provide Culvert Foundation Material with a maximum of **15%** passing the sieve in addition to the requirements of Subsection 701.04.2.

##### C. Construction.

- 1) Excavate a zone as shown elsewhere in the Contract and 2.0 ft below the planned bedding elevation.
- 2) Place geotextile as shown elsewhere in the Contract or as directed by the Project Manager. Overlap any adjoining edges of the geotextile a minimum of 3.0 ft with the edge of the upgrade sheet over the edge of the downgrade sheet.

- 3) Place the first 16 inches of Foundation Material over the geotextile with the least amount of compaction effort necessary to create a stable base, with the least amount of equipment possible, and otherwise in accordance with Subsection 622.03.

- 4) Do not use vibratory, studded, or sheepfoot rollers on the first 16 inches.

- 5) Place subsequent lifts in accordance with Subsection 622.03.

##### D. Method of Measurement.

- 1) Culvert Foundation Material is measured in accordance with Subsection 603.04.

- 2) Geotextile is measured in accordance with Subsection 622.04.

E. Basis of Payment. Payment is full compensation for all labor, tools, equipment and other incidentals necessary to complete the work in accordance with the specifications and as directed by the Project Manager.

- 1) Culvert Foundation Material is paid in accordance with Subsection 603.05.
- 2) Geotextile is paid in accordance with Subsection 622.05.



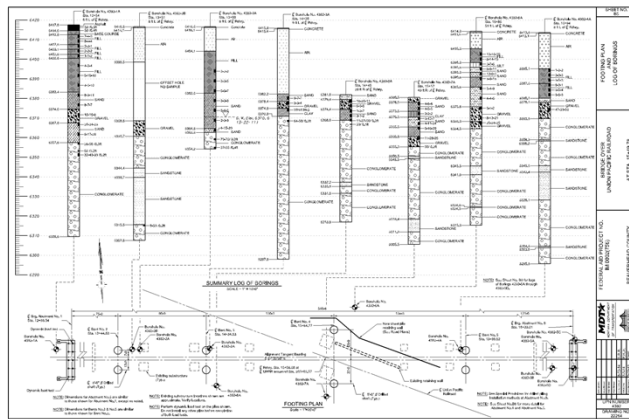
# Structure Foundations

## Type



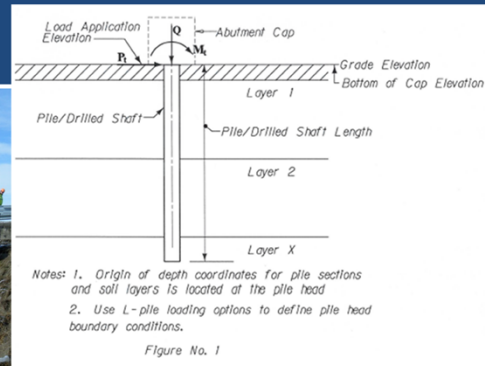
# Structure Foundations

## Size/Depth



# Structure Foundations

## Other Considerations



Lateral loads (Ice, Seismic, Impact), liquefaction, lateral spread

# Structure Foundations

## Constructability

MT Geotechnical  
CN4060-Musselshell\_Bridge-Bent 1

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
6.0	37.8	1.5	36.3	3.2	13.237	-1.878	4.99	23.5
12.0	42.3	6.0	36.3	3.5	13.563	-1.777	5.07	23.2
18.0	306.3	114.3	192.0	47.1	22.591	-1.438	7.63	17.9
21.0	370.7	178.8	192.0	59.1	23.420	-1.872	8.11	18.0
23.0	413.7	221.7	192.0	69.1	24.170	-2.356	8.30	18.1
25.0	456.6	264.6	192.0	81.5	25.380	-2.616	8.48	18.1

Total Continuous Driving Time 14.00 minutes; Total Number of Blows 610 (starting at penetration 6.0 ft)

SEP 20 2016  
GRLWEAP Version 2010

**CN4060-Musselshell\_Bridge-Bent 1**

Information  
in following list (12/4/2015:2003)

Name	Type	Param	Value	Energy/Stroke
DELMAG D 19-32	DEO	4.0000	42.440	
DELMAG D 19-42	DEO	4.0000	43.240	
DELMAG D 200-42	DEO	44.0000	432.044	

Resistance Gain/Loss Factor

Shaft	Toe
1	1.0
2	0.5
3	0.0
4	0.0
5	0.0

Inc.

Soil Parameters

Quake  
Shaft  in   
Toe  in

Damping  
Shaft  u/r   
Toe  u/r

Shaft Resistance  
Percentage  %

Dist. Shape Num

Residual Stress Analysis

File material  
☒ Concrete ☒ Steel ☐ Timber

Cushion Information


Hammer	File
Area	415.0 in <sup>2</sup>
Elastic Modulus	5.39 ksi
Thickness	2.0 in
C.O.R.	0.8
Stiffness	0.0 kips/in
Hebel Weight	3.4 kips

File Information

Length	Penetration	Section Area	Elast Modulus	Spec Weight	Toe Area	Perimeter	Pile Size
30.0 ft	25.0 ft	30.63 ft <sup>2</sup>	30457.9 ksi	493.355 lb/ft <sup>3</sup>	314.159 in <sup>2</sup>	5.236 in	20 in

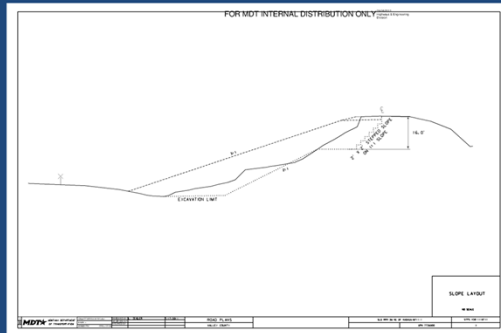
Segments  
S-Length  
S-St. Wt  
Splices

File Type  
☒ Force



# Landslide Corrections

## Repair Strategies

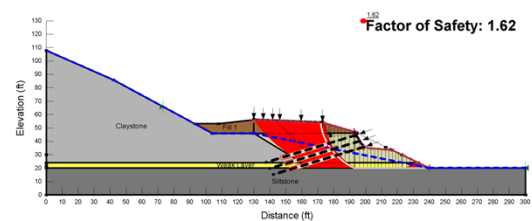


# Landslide Corrections

## Analysis



Sld Rpr - 5 Mi E Lame Deer  
Soil Nails (STA 21+26)  
Long Term w/ Water  
Internal Stability



MATERIAL	MATERIAL MODEL	UNIT WEIGHT (pcf)	COHESION (psf)	PHI (degrees)
Fill 2	Mohr Coulomb	120	50	25
Claystone	Mohr Coulomb	140	3,000	0
Siltystone	Bedrock (Impenetrable)			
Fill 1	Mohr Coulomb	125	0	35
Weak Layer	Mohr Coulomb	120	50	15

Notes:  
Soil Length: 60 ft  
Soil Spacing: 10 ft  
Soil Spacing: 5 ft  
Soil Spacing: 0.5 ft  
Unfactored Bond Resistance (GFR): 2000 psf  
Unfactored Bond Resistance (GFR): 1000 psf  
Method: Morgenstern-Price  
Direction of Movement: Left to Right  
Soil Surface Condition: Dry and Erodible  
GFR Conditions: Steep, Frictionless Line  
Minimum Soil Surface Depth: 5 ft

Legend:  
Materials  
Fill 2  
Claystone  
Siltystone  
Fill 1  
Weak Layer

Forensic, Mitigation



## Unusual Geotechnical Features

- Subsurface Voids
- Expansive Soils
- Collapsible Soils
- Frost Heave
- Forensic Evaluations





## Questions

